STATUS OF GYPSY MOTH POPULATIONS AT BLACKWATER NATIONAL WILDLIFE REFUGE, 1995-96

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ABSTRACT

On October 23-25, 1995, USDA Forest Service, Forest Health Protection personnel conducted a gypsy moth egg mass survey at Blackwater National Wildlife Refuge. The purpose of the survey was to assess the need for treatment in 1996 to protect Delmarva Peninsula fox squirrel habitat. Current populations are sufficient to cause moderate to heavy defoliation on about 1022 acres in 1996. Treatment is recommended for this area using *Bacillus thruingiensis* subspecies *kurstaki*.

METHODS

The survey area consisted of stands that were previously identified as being fair to good fox squirrel habitat with a moderate to high potential for gypsy moth defoliation (Whiteman and Onken, 1994). The survey also included approximately 440 acres of forest in the Church Creek area that was acquired at a later date. All stands treated in the 1995 gypsy moth suppression project were included in the egg mass survey.

Within each stand, gypsy moth survey plots were randomly selected based upon available host trees (oak and sweet gum), size of sample area, uniformity between egg mass counts and available time. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (1995) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was then multiplied by 40 to determine egg masses per acre.

Color infrared aerial photography (scale 1:12,000) taken in late June was used to estimate gypsy moth-caused defoliation and in conjunction with the egg mass survey results, identify areas where consecutive years of defoliation could occur. The imagery was obtained by contract with the USDA Forest Service Aerial Photography Group, Atlanta, Georgia.

RESULTS

The 37 stands surveyed are presented in Figure 1-2E and summarized in Table 1. Throughout the survey area, egg mass densities ranged from 0 to 11,480 and averaged 1460 egg masses per acre. Eighteen stands had egg mass densities that averaged over 1,000, three averaged between 500-1000 and sixteen averaged less than 500 egg masses per acre. Localized "hot spot" populations (> 1000 egg masses/acre) were noted in five of the stands that averaged less than 1000 egg masses per acre. Egg mass size was quite variable throughout the survey area and ranged from a dime to a quarter in size.

Defoliation occurred on a total of 116 acres within the refuge (Figure 3). Current egg mass densities throughout much of the defoliated area (85 acres) exceed 1000 egg masses per acre. Gypsy moth populations elsewhere in the defoliated area are at low densities.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as: light (1-30 percent); moderate (31-60; and heavy (61-100 percent).

Gypsy moth populations are sufficient to cause heavy defoliation in 1996 throughout much of Stands 21, 23, 27, 29, 32-35, 37, 39-41, 44, 51, 56, 57, 64 and 65. These eighteen stands encompass 897 acres. Areas of

heavy defoliation are also likely to occur in parts of Stands 4, 7, 12, 38 and 63. These five areas encompass 125 acres. No noticeable defoliation is likely elsewhere at Blackwater National Wildlife Refuge in 1996.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. A more immediate and direct effect of defoliation on fox squirrel populations is through the loss of oak mast. This occurs primarily from caterpillar feeding damage to flowers as well as the foliage. Excessive foliage loss causes a lack of carbohydrates which results in the abortion of immature acorns. It is possible to have up to 5 years of complete acorn failure during and following years of moderate to heavy defoliation (Gottschalk, 1990).

In general, trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (<60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Previous gypsy moth-caused defoliation occurred at Blackwater NWR in 1993 (598 acres), 1994 (988 acres) and 1995 (116 acres). Severe droughty conditions also occurred throughout the Eastern Shore in 1995. Figures 3 and 4 show the location of the affected areas for each year.

An example of the potential tree mortality that could occur is provided by the Allegheny National Forest. In untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In this example, droughty conditions likely contributed to the level of mortality.

The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

Management Options

For 1996, two management options have been evaluated for managing gypsy moth populations at Blackwater National Wildlife Refuge. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent mast failures and tree mortality; and 2) reduce subservent gypsy moth populations below the treatment threshold of 750 egg masses per acre. Each is discussed below and considers the primary resource management objective of protecting Delmarva fox squirrel habitat.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) and/or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before

rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is likely that a collapse will occur in stands that have high densities in a declining population. However, it is likely that even these stands will be defoliated before the population collapses. In stands with a building population, a collapse is not likely in 1996.

Should this option be selected, it is likely that defoliation will occur on at least some of the 1022 acres and building populations will continue to increase and expand to currently uninfested areas of the Refuge.

Microbial Insecticide Option

B.t.

The second option is to use a microbial insecticide to manage gypsy moth populations. The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringiensis* subspecies *kurstaki* (*B.t.*). This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *B.t.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. Although *B.t.* is considered to be more host specific than DFB, it has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. *B.t.* is persistent on foliage for about 7-10 days.

B.t. formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double applications. *B.t.* can be applied either undiluted or mixed with water for a total volume of 1/2-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *B.t.* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek

The nucleopolyhedrosis virus (NPV) product, Gypchek, is another microbial insecticide that can be used. Gypchek is not yet available commercially, but the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS) has registered and produced the product in limited quantities. The NPV is host specific and occurs naturally in gypsy moth populations. Normally, the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations.

To date, the efficacy of Gypchek treatments to reduce gypsy moth populations has been somewhat variable. Because of the short period of viral activity on foliage (5-6 days) as well as other biological factors such as feeding activity and weather conditions, it is difficult to project treatment efficacy. We do expect however, that adequate foliage protection would be achieved.

The standard application rate of Gypchek is $2x10^{11}$ polyhedral inclusion bodies (PIBs) per acre. In addition to the virus the formulation includes a carrier and unchlorinated water which are added in a total mix of 1 gallon per acre. The treatment requires that two applications be applied three days apart.

Alternatives

With the previously described options in mind, the following four (4) alternatives are offered.

Alternative 1.	--	No action.
Alternative 2.	--	Two aerial applications of *B.t.* at the rate of 36 BIUs in a total mix of 3/4 gallon per acre. The second application, where necessary, should be applied 4-7 days following the first.
Alternative 3.	--	Two aerial applications of Gypchek applied at the rate of $2x10^{11}$ PIBs in a total mix of 1 gallon per acre. The application should be applied 3 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient to cause widespread heavy defoliation in eighteen stands covering 897 acres and isolated areas of heavy defoliation in five stands covering 125 acres (Figure 4). As a result, some direct action is recommended to protect tree foliage, mast production, and prevent tree mortality.

Alternative 2 is recommended based on the following considerations:

1) Gypsy moth population densities are very high in many of these stands and a single application of *B.t.* will not likely provide adequate population reduction, particularly stands with building populations.

2) Most of these stands have had some defoliation in the past two years and this alternative will offer the best chance of protecting host foliage in 1996.

3) Gypchek is more expensive (3-5 times the cost of *B.t.*) and treatment efficiency is much more variable.

4) Although *B.t.* could have a short term impact on other susceptible caterpillars, no known rare, threatened or endangered species are within the treatment area.

REFERENCES

Gottschalk, K.W. 1990 Gypsy Moth Impacts on Mast Production, IN: McGee, Charles E. ed. Proceedings of the Workshop, Southern Appalachian Mast Management; 1989 August 14-16; Knoxville TN: University of Tennessee; 42-50.

Whiteman, R.L., and B.P. Onken, 1994. Protecting Delmarva Fox Squirrel Habitat from Gypsy Moth and Southern Pine Beetle, Blackwater National Wildlife Refuge, 1994. Unpublished Report, 46pp.

Table 1. -- Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, October 23-25, 1995.

Stand Number	Plot Number	Number EM/Acre
1	1 2 3 4	520 40 360 80 Range = 40 - 520 Average = 250
3	5 6	480 480 Average = 480
4	7 8 9 10 11	40 0 2240 160 760 Range = 0 - 2240 Average = 640
5	12 13 14	560 0 160 Range = 0 - 560 Average = 240
6	15 16 17 18 19 20	160 560 280 40 80 0 Range = 0 - 560 Average = 187
7	21 22 23 24	0 200 80 1000 Range = 0 - 1000 Average = 320
9	25 26 27	240 80 0 Range = 0 - 240 Average = 107
10	28 29	0 40 Range = 0 - 40 Average = 20
11	30 31	0 120 Range = 0 - 120 Average = 60
12	32 33 34 35 36 37 38 39	200 1720 280 40 40 240 0 160 Range = 0 - 1720 Average = 335
13	40 41 42	0 0 360 Range = 0 - 360 Average = 120
20	43 44	0 40 Range = 0 - 40 Average = 20
21	45 46	5480 3360 Range = 3360 - 5480 Average = 4480
23	47 48	6200 11,480 Range = 6200 - 11,480 Average = 8840
27	49 50 51	4240 4720 920 Range = 920 - 4720 Average = 3293
29	52 53 54 55	120 120 3640 4360 Range = 120 - 4360 Average = 2060

Table 1. (cont.) -- Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, October 23-25, 1995.

Stand Number	Plot Number	Number EM/Acre
32	56 57	1160 1560 Range = 1160 - 1560 Average = 1360
33	58 59	2360 3840 Range = 2360 - 3840 Average = 3100
34	60 61	4960 720 Range = 720 - 4960 Average = 2840
35	62 63 64 65 66	3400 4000 6880 3000 4160 Range = 3000 - 4160 Average = 4288
37	67 68 69 70	1080 4720 200 3680 Range = 200 - 3680 Average = 2420
38	71 72	1440 120 Range = 120 - 1440 Average = 780
39	73 74	2520 1680 Range = 1680 - 2520 Average = 2100
40	75 76	2800 2600 Range = 2600 - 2800 Average = 2700
41	77 78	2200 1720 Range = 1720 -2200 Average = 1960
44	79 80	5240 1240 Range = 1240 - 5240 Average = 3240

Stand Number	Plot Number	Number EM/Acre
51	81 82	2000 2600 Range = 2000 - 2600 Average = 2300
56	83 84 85	1560 240 7680 Range = 240 - 7680 Average = 4740
57	86 87	9080 6400 Range = 6400 - 9080 Average = 7740
58	88 89	0 520 Range = 0 - 520 Average = 260
60	90	120
61	91 92 93 94 95	0 160 120 320 280 Range = 0 - 320 Average = 176
62	96 97 98	0 0 200 Range = 0 - 200 Average = 67
63	99 100 101	40 1480 520 Range = 40 - 1480 Average = 680
64	102 103 104 105	1240 2320 2760 1040 Range = 1040 - 2760 Average = 1840

Table 1. (cont.)- Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, October 23-25, 1995.

Stand Number	Plot Number	Number EM/Acre
65	106 107 108	5920 720 160 Range =160 - 5920 Average = 2267
66 *	109 110 111 112 113 114 115 116 117 118 119 120	840 320 240 280 200 120 120 200 720 360 80 440 Range = 80 - 840 Average = 327
Total Average = 1460 EM/Acre		

* Stand 66 was delineated using aerial photography and encompasses most of the oak and oak-pine cover types on the Ewing tract.

Figure 1. -- Stands surveyed for gypsy moth egg masses at Blackwater National Wildlife Refuge, October 23-25, 1995.

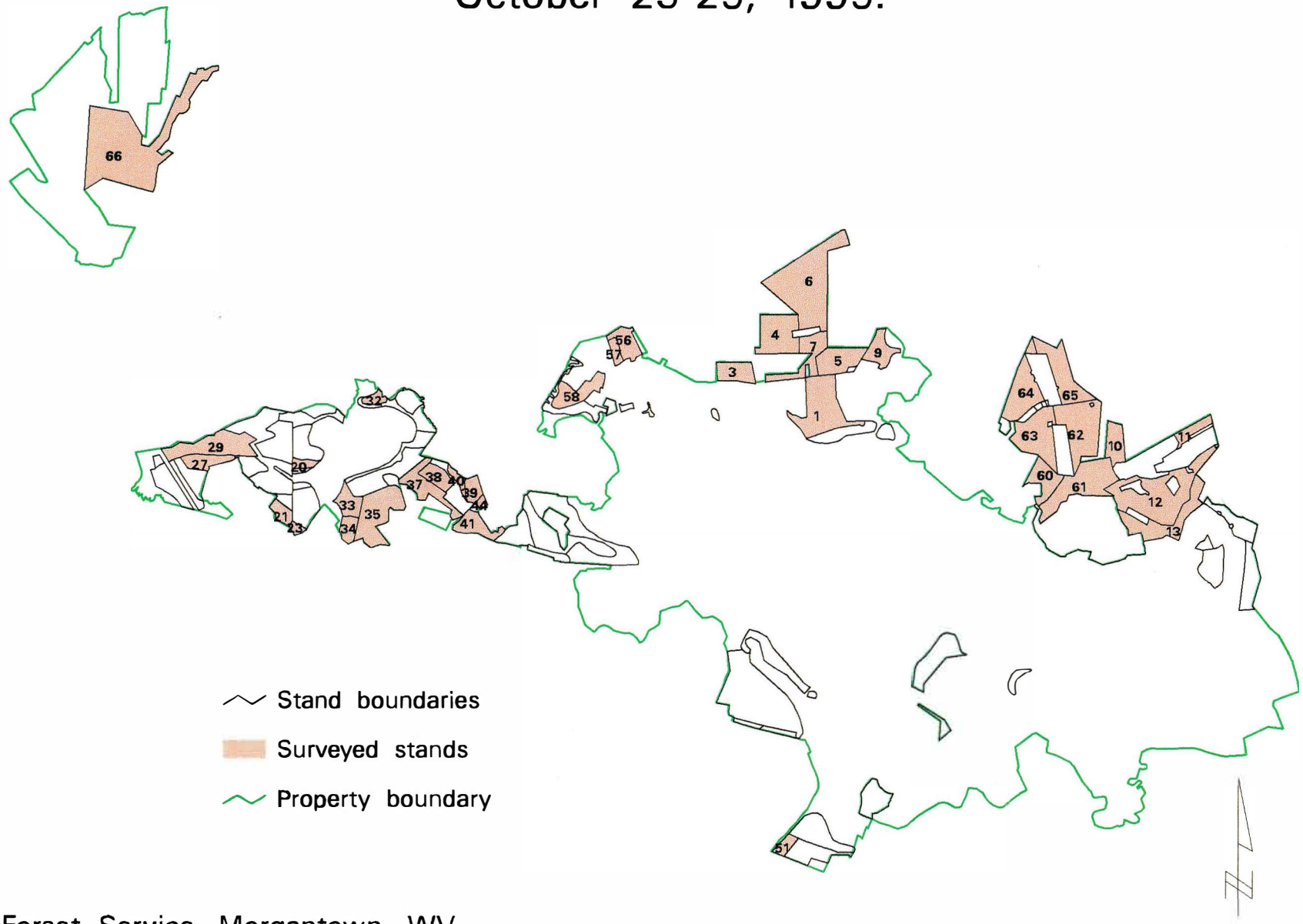

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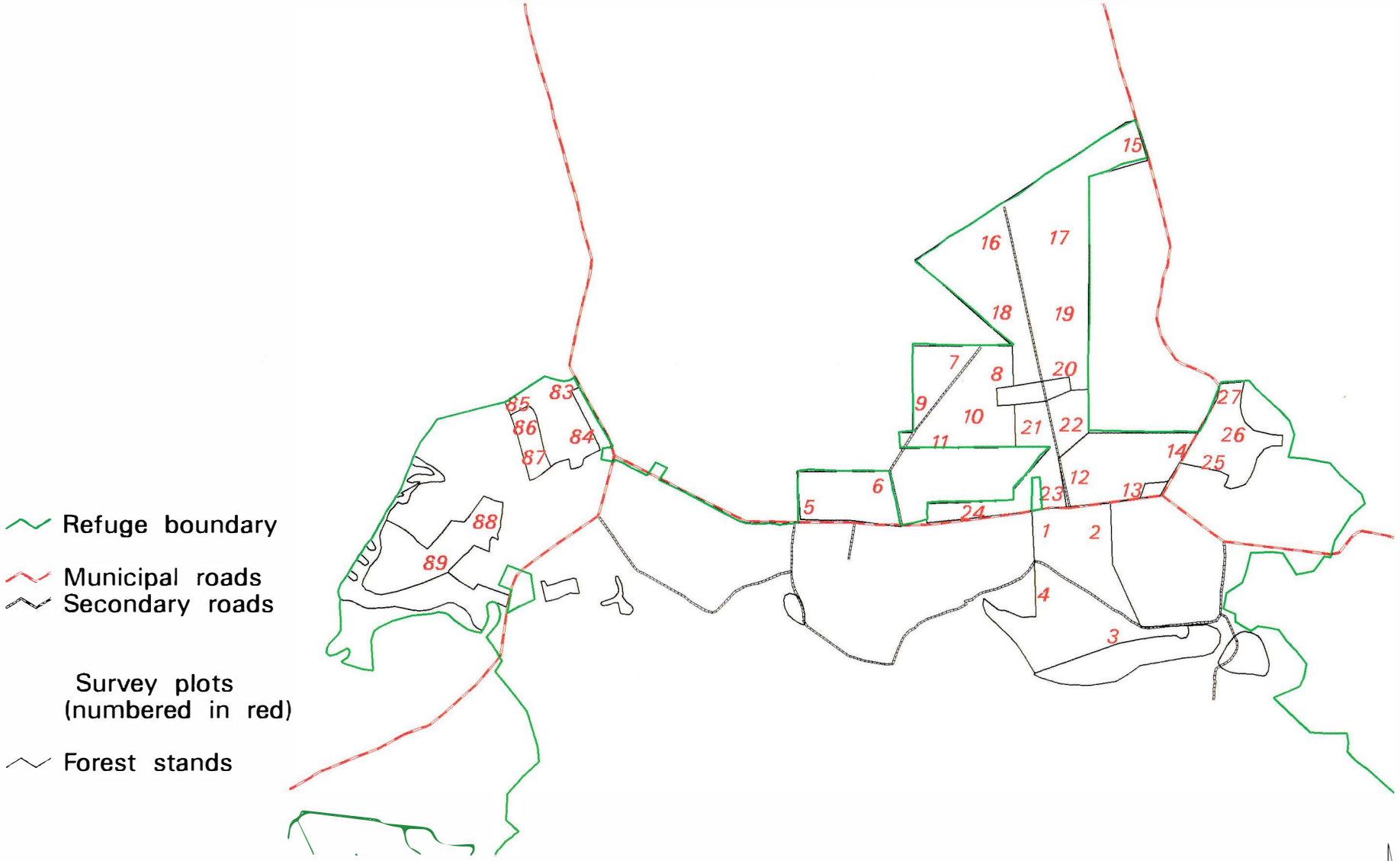
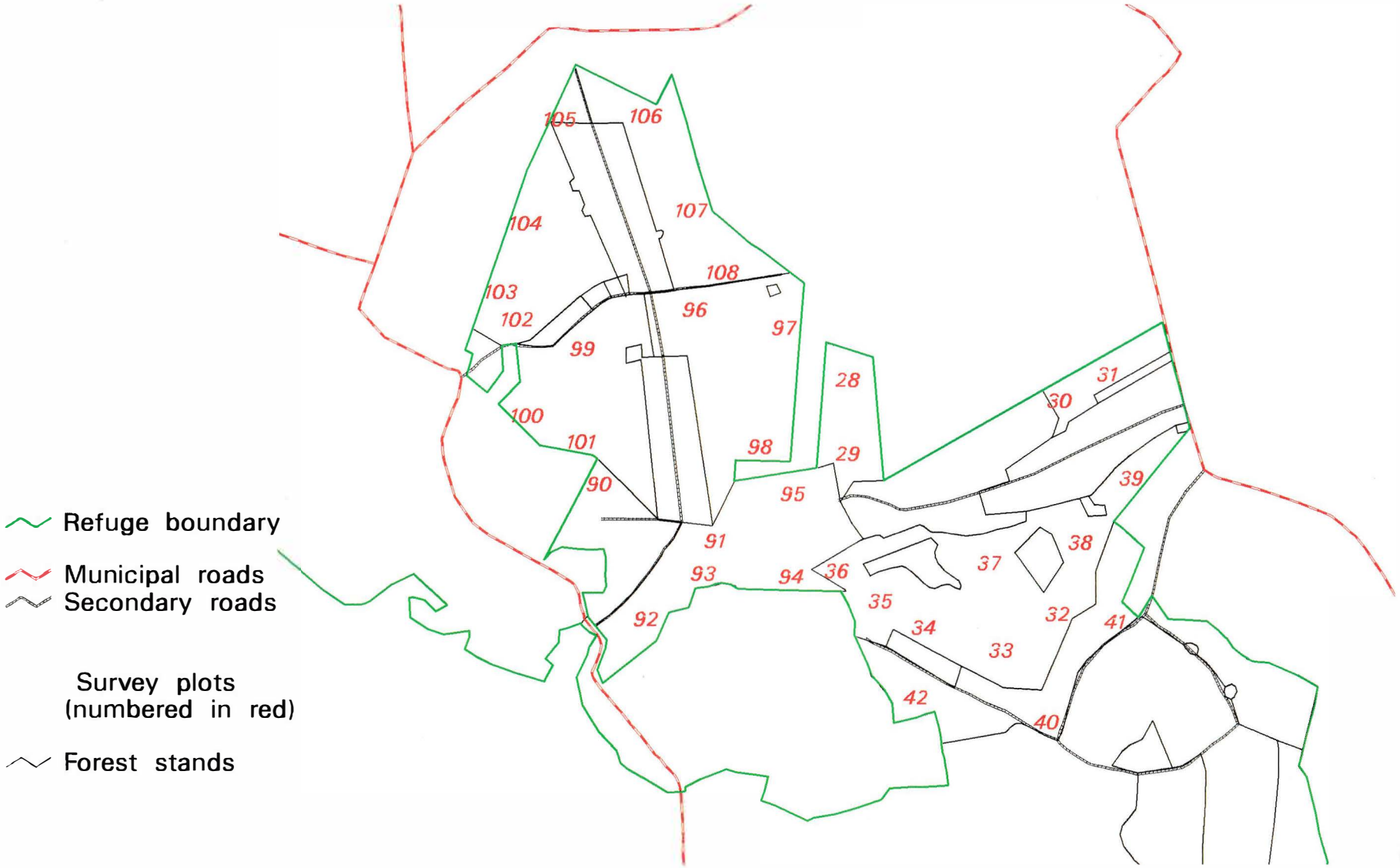
Figure 2a. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, October 23-25, 1995.



USDA Forest Service, Morgantown, WV

Figure 2b. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, October 23-25, 1995.



USDA Forest Service, Morgantown, WV

Figure 2c. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, October 23-25, 1995.

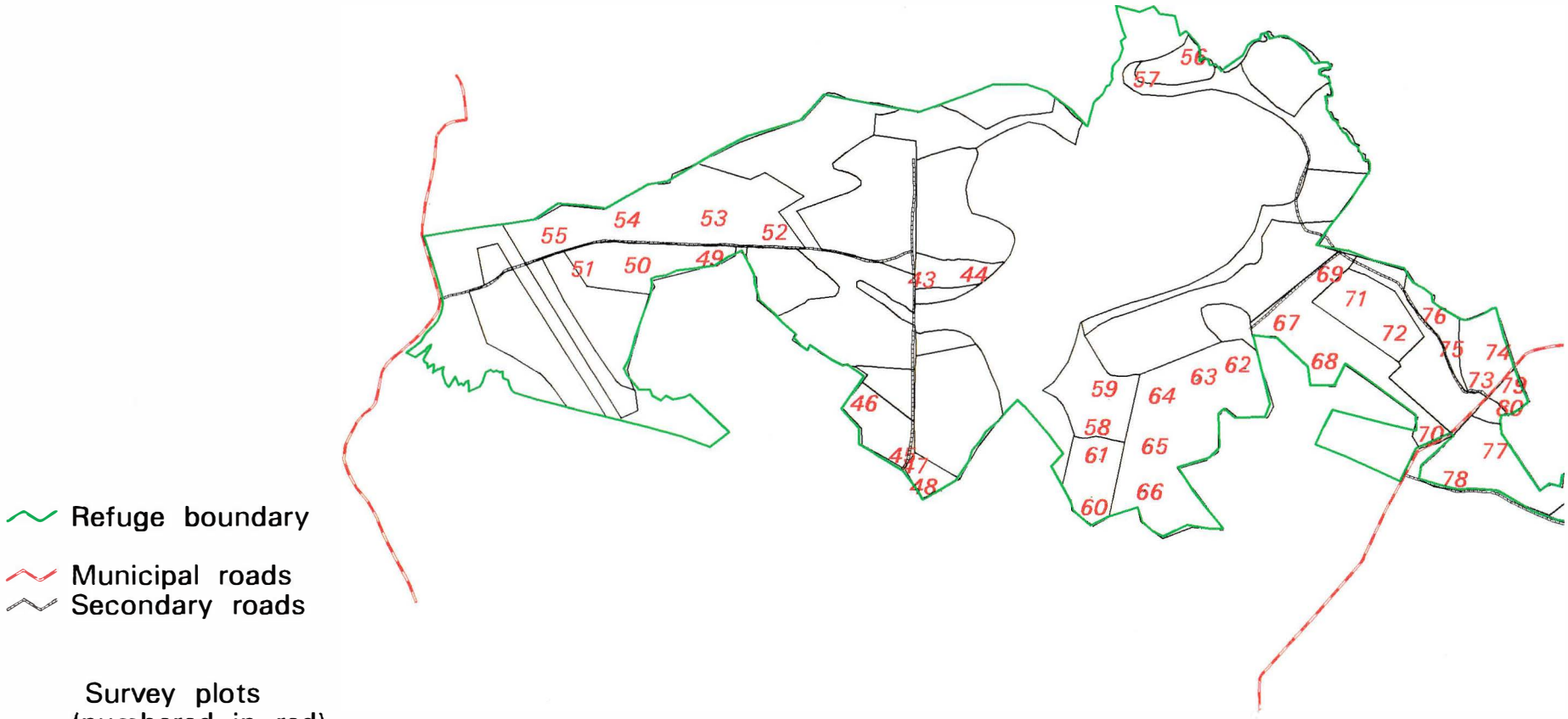


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Figure 2d. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, October 23-25, 1995.

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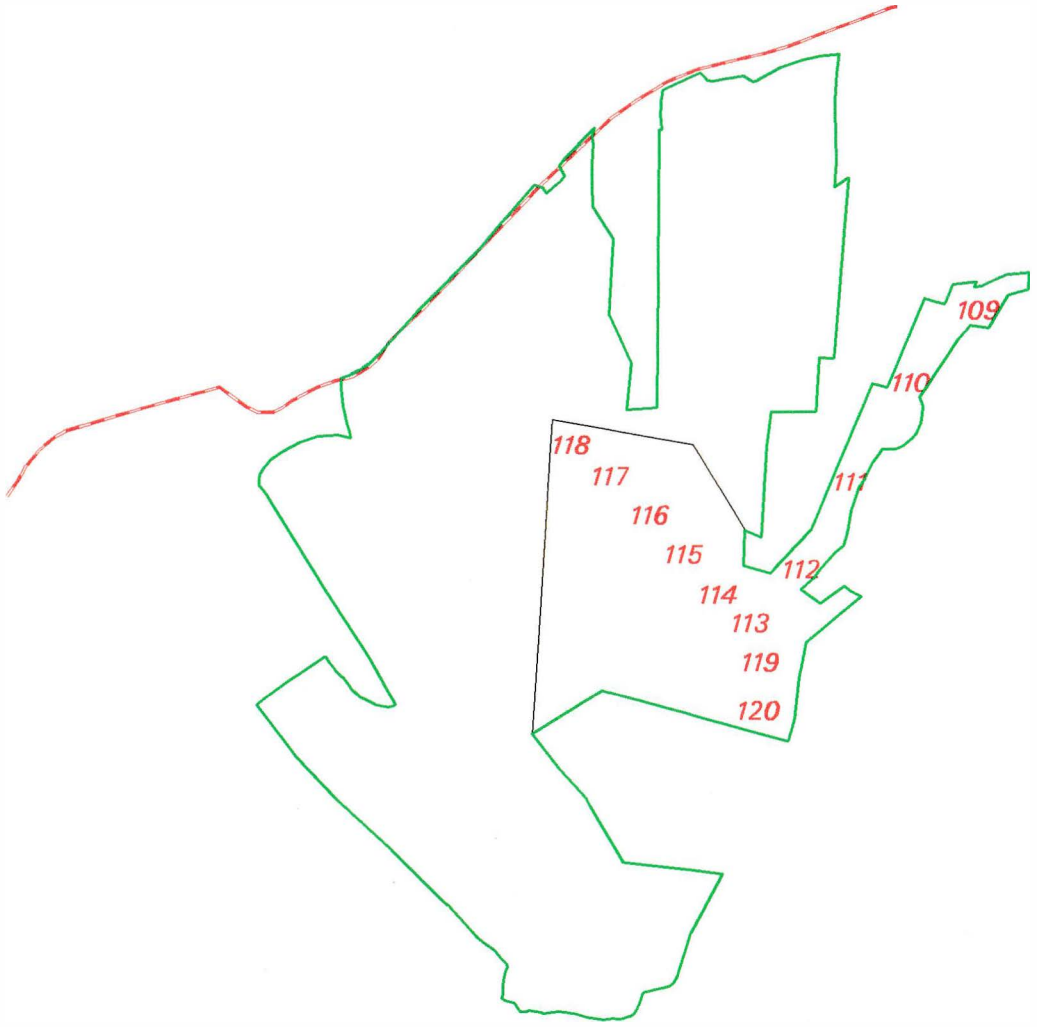
Figure 2e. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, October 23-25, 1995.



Refuge boundary

Municipal roads
Secondary roads

Survey plots
(numbered in red)

Forest stands

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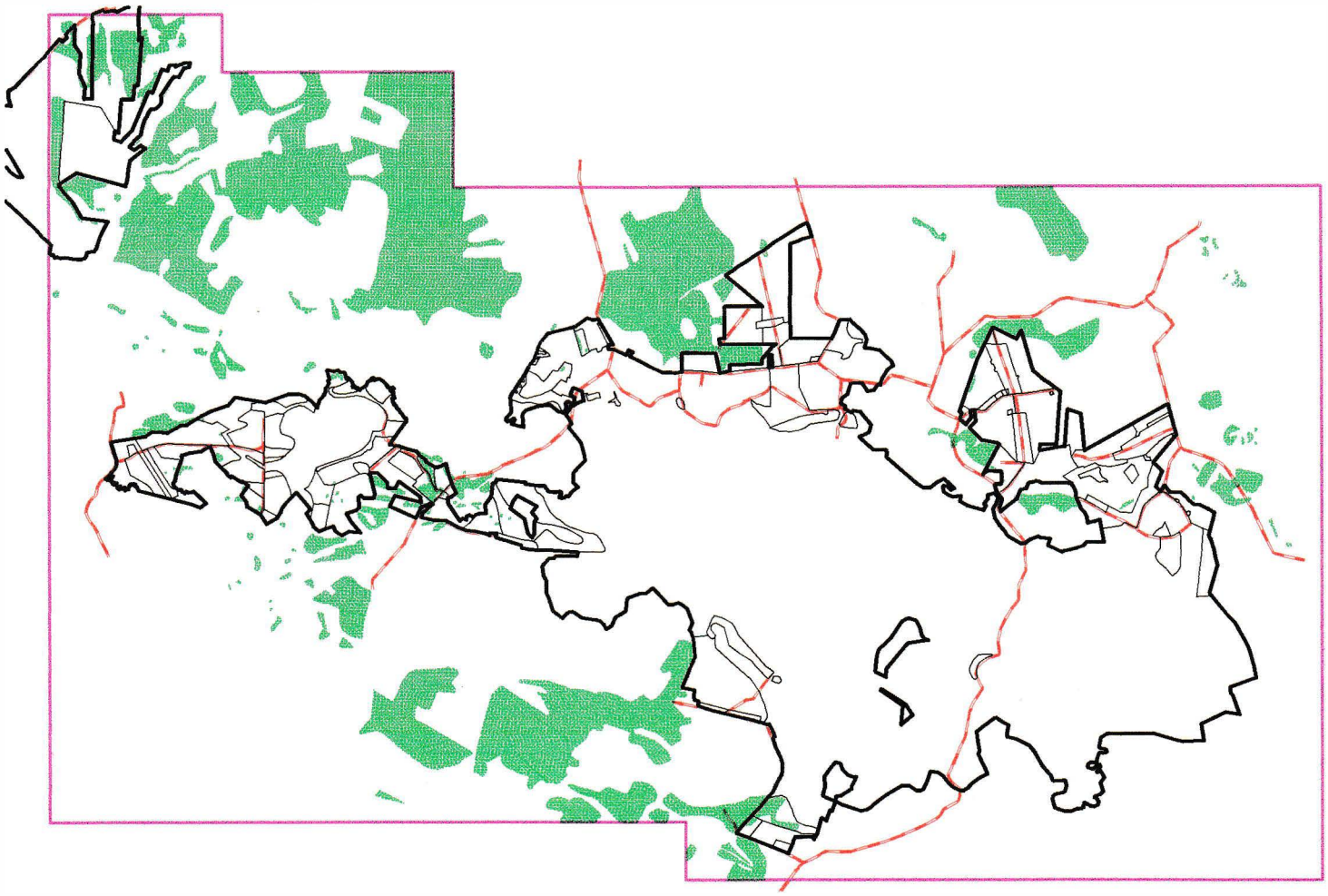
Figure 3. -- Gypsy moth defoliation at Blackwater National Wildlife Refuge and vicinity in 1995.



Note: Results obtained through interpretation of aerial photographs

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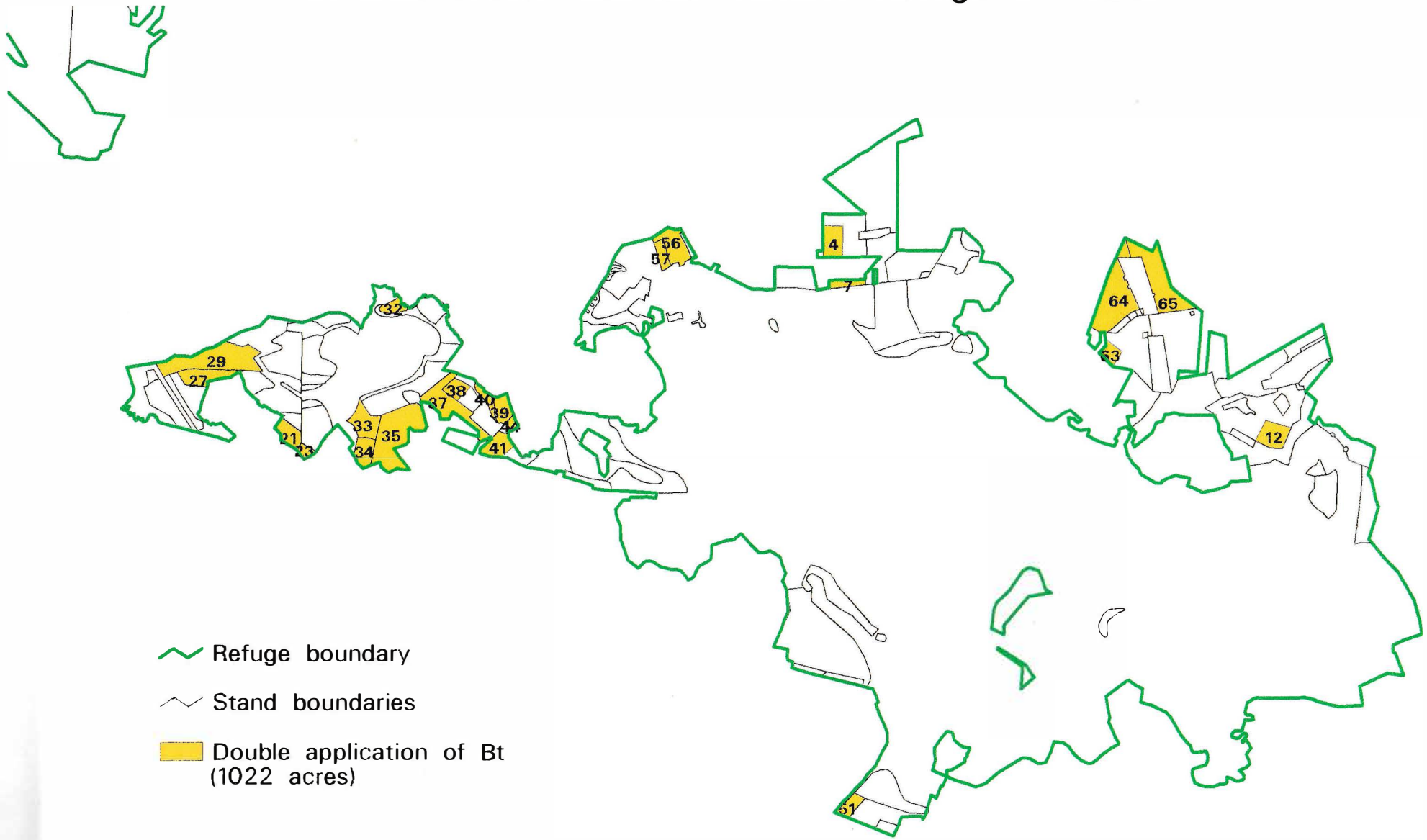
Figure 4. -- Proposed gypsy moth treatment areas at Blackwater National Wildlife Refuge in 1996.



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